Interpolation Procedures in CAPT

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1. Background

In transferring data from analyses to the model grid mesh two separate interpolations need to be carried out, the horizontal and vertical. The 'fullPos', *White* (2002), procedures refer mainly to the vertical and more specifically to the extrapolation beyond the lower boundary. The vertical structure of the models used thus far can be expressed in term of the generalized pressure coordinates, η. The pressure of the η coordinates at a level i is given by:

$$p_i = a_i * p_0 + b_i * p_{sfc} \tag{1}$$

where p_0 is a reference pressure (often 1000 hPa). If the a_i are zero then this formulation reverts to σ coordinates. Generally, the a_i and b_i are specified such that the coordinates transition from pure σ at the lowest levels to pure pressure at the upper levels. Figure 1 illustrates the undulating nature of the lower boundary. This lower boundary conforms to the surface pressure which is a strong function of the model topography. The CAM and analyses (e. g. ERA40, DAO, GDAS) will have different representations of the earth's topography. These differences can be substantial. The key procedures which were taken from the 'full pos' document are meant to deal with those occasions in which there is a terrain mismatch and to produce a reasonable extrapolation/interpolation. This is essentially an engineering problem. There is no 'right' answer for the winds 300 meters below the surface of the re-analyses. However, the ECMWF uses its long experience to establish techniques to ensure reasonable fields even in pathological cases. All operational forecast centers have developed these methods but the ECMWF has published a comprehensive description, *White* (2002), which facilitates their adoption.

2. horizontal interpolation

The ECMWF describes a number of horizontal interpolation options, linear, quadratic etc. These are fairly standard techniques.

a. *Cubic*

Jerry Olson implemented a cubic interpolation scheme for going from one latitude, longitude grid to another. This works fine for the gaussian grids but if a pole point (90°N, 90°S) exists in either grid then his algorithm fails.

b. *conservative re-mapping*

Karl Taylor wrote a scheme to accomplish a conservative re-mapping. It is conservative in the sense that the areal mean of the scalar variable remains the same during the re-mapping from one grid to another. This scheme tolerates a pole point and so is used for the finite volume gridpoint models.

3. vertical interpolation

There are different techniques used for each of the dynamical variables, U,V,T, Q. The main engine is a linear interpolation in log p. The differences are in the extrapolations/adjustments, if necessary, at the end points. For the temperature, efforts are made to maintain a hydrostatic column, for moisture care is taken not to exceed saturation, and to extrapolate relative humidity not specific humidity.

4. Smoothing

In the aftermath of the interpolation, there will be artifacts produced in the new fields which need to be removed to provide as stable an initial state for the model as possible. For the gaussian grids, the smoothing is done in spherical harmonic space using the technique of *Sardeshmukh and Hoskins* (1984) to minimize ringing from the truncation. For the non-gaussian grids there are two smoothing options. One is a filter developed by Joe Gerrity at NCEP, *Gerrity* (1971). This Gerrity filter was designed to get rid to $2\Delta x$ noise in the regional model output. The other filter is one designed by Rainer Bleck (part of his master's thesis) to eliminate $2\Delta x$ noise. Rainer used this when interpolating to θ coordinates to run his isentropic model , which is analogous to our situation.

5. Sequence of Procedures

For each analysis time (6h at present)

1. Interpolate surface height of Analyses(Z^{A}_{sfc}) to Model grid,($Z^{A->M}_{sfc}$)
2. Smooth $Z^{A->M}_{sfc}$ with the appropriate technique
3. Interpolate surface pressure of Analysis (p^{A}_{sfc}) to model grid, ($p^{A->M}_{sfc}$)
4. Smooth $p^{A->M}_{sfc}$ with the appropriate technique
5. Surface Pressure Adjustment. Taking into account the difference in the topography representation of the analysis and the model - ($Z^{A->M}_{sfc}$ and Z^{M}_{sfc}), adjust the $p^{A->M}_{sfc}$ to create a reference surface pressure, $p^{A->M}_{sfcAdj}$. This field is used for future η calculations. This adjustment requires the full analysis temperature field which is interpolated and smoothed in the exact same fashion as the surface pressure to maintain consistency.
6. using $p^{A->M}_{sfcAdj}$ compute the pressures of the models η coordinates for this time step.
7. For each variable:
   (a) Interpolate from the Analysis grid to the model grid.
   (b) Smooth
   (c) Interpolate vertically from the analysis' η to the model's η. Use different routines for temperature, specific humidity and winds. Enforce consistency of the temperature with the adjustments to the surface pressure made above.

References

Gerrity, J. P. (1971), Office note 57: Digital filters for use in post-processing forecast fields, *Tech. rep.*, National Meteorological Center, NWS, Silver Springs, MD.

Sardeshmukh, P. D., and B. I. Hoskins (1984), Spatial smoothing on the sphere., *Mon. Wea. Rev.*, *112*(12), 2524–2529.

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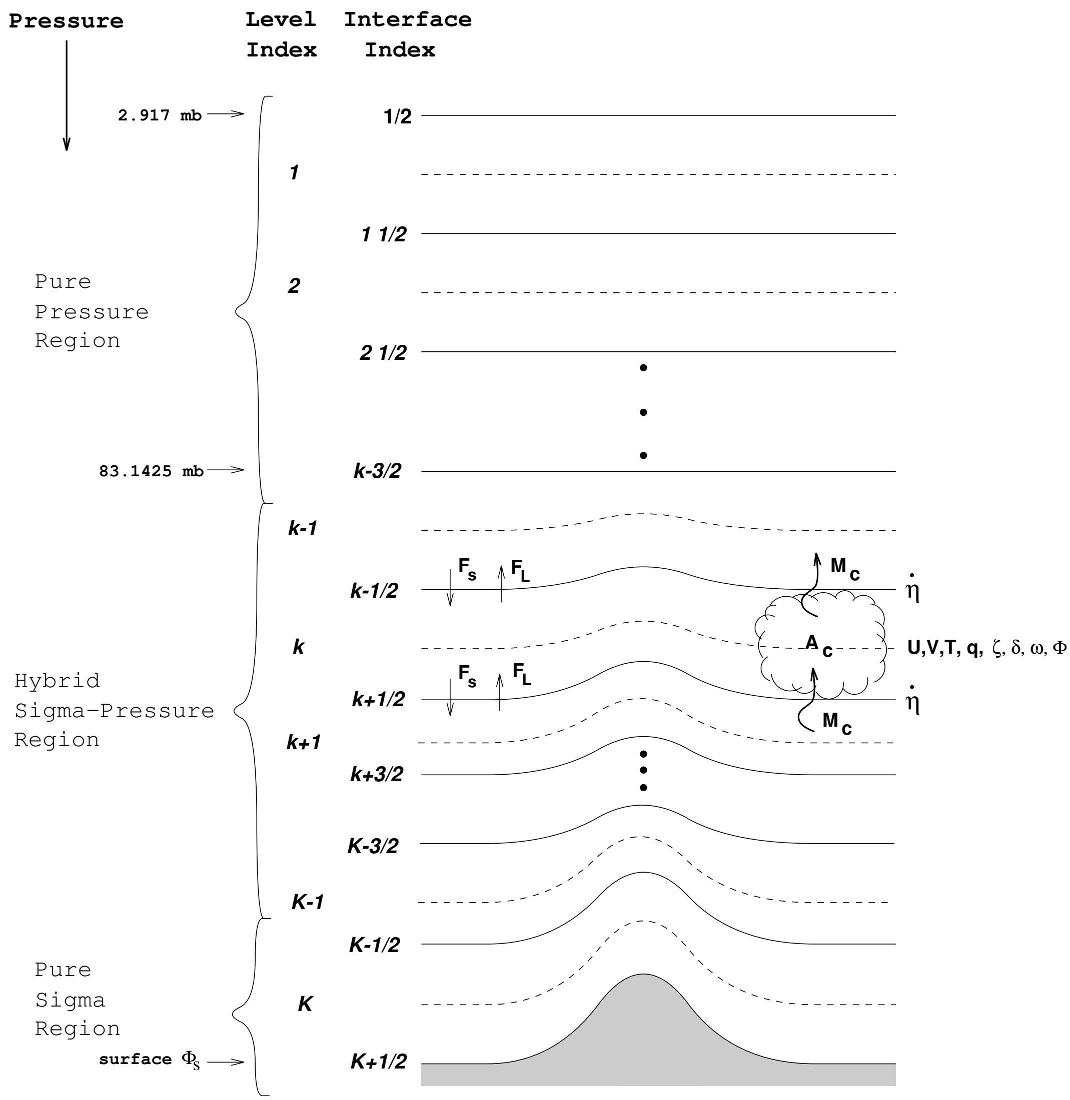

Figure 1: CAM vertical structure